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ABSTRACT

To study the effects of practice and incentive on learner performance on the aircraft instrument comprehension task, 48 third-year Air Force cadets were chosen as subjects. The subjects were expected to be able to identify which one of four pictures of aircraft in flight most nearly corresponded to the position indicated on a panel of attitude and heading instruments. Incentives were in the form of additional points and an opportunity to "fly" a formation trainer. The practice variable was manipulated by changing the instructional materials. The pretest-treatment-post-test experimental design provided data for analysis. Data revealed that neither variable (practice or incentive) significantly affected the accuracy of post-test responses, but they did affect in a positive way the post-test rate of responding. The rate of responding is often considered to be a good indicator of an individual's productivity. Sample instructional materials and a post-test item are appended. (AG)

AFHRL-TR-74-104

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PRACTICE AND INCENTIVE EFFECTS ON LEARNER PERFORMANCE:

AIRCRAFT INSTRUMENT COMPREHENSION TASK

By

Arizona State University
Tempe, Arizona 85281

FLYING TRAINING DIVISION
Williams Air Force Base, Arizona 85224

December 1974
Final Report for Period June 1973 – July 1974

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WILLIAM V. HAGIN, Technical Director
Flying Training Division

Approved for publication.

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AFROTC cadets learned an aircraft instrument comprehension task by reading self-instructional materials. No significant changes in posttest scores occurred when practice items were added to the materials or when simulator rides were offered as incentives. However, cadets who practiced the task and cadets who were offered the incentive performed faster on the posttest than those who only read the materials.

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PREFACE

This study was conducted under Project 1123, USAF Flying Training Development, Task 1123-02, Instructional Innovations in USAF Flying Training.

The research was carried out under provisions of contract F41609-71-C-0027 by the Educational Technology Department of the College of Education, Arizona State University.

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PRACTICE AND INCENTIVE EFFECTS ON LEARNER PERFORMANCE: AIRCRAFT INSTRUMENT COMPREHENSION TASK

The present study is one of several related research and development efforts. The instructional task for these studies is the aircraft instrument comprehension task.

The series of studies has been initiated in an attempt to identify potentially powerful variables in an effective instructional program. The aircraft instrument comprehension program used in these studies was systematically designed to include instructional cues, examples, prompted and unprompted practice items, feedback, and an incentive. Two tryouts of the program were conducted to verify that the students could learn the task from the program. The program's effectiveness was established when 80 percent of the subjects in the second tryout met the instructional objective of the program.

During the two program tryouts, an experiment was conducted to determine the effect of feedback on posttest performance. The answers to the practice items in the instructional program were available to some subjects, but were not available to the other subjects. It was found that the availability of feedback in this form did not make a statistically significant difference in posttest performance.

The purpose of the present study was to determine the effects of practice and incentive on learner performance on the aircraft instrument comprehension task. Practice and incentive were selected from among the potentially powerful variables that had been systematically included in the program, but that had not yet been manipulated. This study was designed

to determine the effects of practice and incentive when used with instruction. Therefore, instruction was not manipulated in the present study although it was recognized as the other potentially powerful variable that was systematically included in the aircraft instrument comprehension program. The design of the present study permitted analyses of the individual and combined effects of practice and incentive in a self-instructional program. The results of the study could be used to facilitate the design of other instructional products for undergraduate pilot training systems.

Method

Subjects--The Ss in the study were 48 third year Air Force cadets enrolled in an aerospace science course at Arizona State University, Tempe, Arizona, during the fall semester of 1973. All of the cadets in the sample had taken the Air Force Officer Qualifying Test. Nearly all Ss in the sample were male students between the ages of 18 and 22.

Materials--This program is designed to teach students to identify which one of four pictures of aircraft in flight most nearly corresponds to the position indicated on a panel of attitude and heading instruments. The program is designed to achieve the following instructional objective:

> Given four illustrations of aircraft varying in roll, pitch, and heading, the student will identify the illustration that most nearly represents the position indicated on a compass and an artifical horizon. An acceptable performance will consist of identifying at least 90% of the correct response alternatives on a 36-item instrument comprehension test.

The instructional program contains instructional cues and approximately five examples for each of the three concepts--roll, pitch, and heading--

presented. In this study, practice and incentive were added to or deleted from the instructional program.

The incentive variable was manipulated by the use of written instructions located at the beginning of the instructional booklet. The instructions to the Ss in the "incentive" condition contained the information that they could earn up to nine quiz points by responding accurately to the items on the posttest. In addition, it was stated in the instructions that the four cadets who answered the posttest with the greatest accuracy in the least amount of time would have an opportunity to "fly" a formation trainer. The instructions to the subject, in the "no incentive" condition, stated that their grade in the course would not be affected by their participation in the tryout, and that the developers would "appreciate their best efforts."

The practice variable was manipulated by changing the instructional materials. In the "practice" versions of the program, two to four practice items followed the instruction for each concept. Each item provided practice for the instructional objective by eliciting a discrimination between two or more positions of aircraft in flight. The multiple-choice practice items were similar to the items on the posttest, although some of the practice items contained only two response alternatives instead of four alternatives. The booklets that included practice contained approximately twice as many pages as the booklets that did not include practice items. A sample of the practice items, that appeared in the practice versions of the program, is contained in Appendix B.

Instructional booklets were prepared for each combination of the practice and incentive variables. One version contained the description

of the incentive and the practice items. The second version contained the description of the incentive, but did not include the practice items. The third version contained the practice items, but not the description of the incentive. The fourth version did not include either the description of the incentive or the practice items.

As described above, all four versions of the instructional materials contained the pages that explained the concepts. A sample of this instruction is contained in Appendix A. The booklets differed by the inclusion or exclusion of practice items, and by the inclusion or exclusion of the description of the incentive.

Procedures--A pretest was administered to all Ss one week prior to the instruction and the posttesting. The pretest consisted of nine items selected to be representative of the items on the posttest. A maximum of three minutes was allowed to respond to the pretest items.

Each S attended one experimental session in order to read the instructional materials and to respond to the posttest items. First, the Ss were instructed to complete the instructional booklet assigned to them. Ss were asked to record their completion times for the instructional booklets. Proctors collected the booklets as the Ss finished them. When all Ss had completed the instructional booklets, the posttest was administered. Ss were again asked to record their completion times, and the test booklets were collected as the Ss finished.

Ss were assigned to treatment groups by a procedure that made it highly unlikely that any Ss in the "no incentive" condition were aware of the incentive. Since the Ss attended class in four different sections, two sections were assigned to the "no incentive" condition and all Ss in the

second two sections were assigned to the "incentive" condition. Within each section, half of the Ss were randomly assigned to the "practice" condition, and the remaining half were assigned to the "no practice" condition. The mean pretest scores of the four groups were nearly identical. Each of the four groups varied from the overall mean score of 6.25 by less than one-fourth of one point.

Criterion Measure--The posttest contained directions, a sample test item as shown in Appendix C, and 36 multiple-choice type test items. Each test item consisted of an instrument display containing an attitude indicator, a heading indicator, and four line drawings of an aircraft in flight.

The test item pool consisted of 72 different positions of an aircraft in flight. Three dimensions of the aircraft's position (pitch, roll, and heading) were systematically varied to create the item pool. Three levels of pitch were used: level, climb, and dive. Three levels of roll were used: no bank, 30^{0} right-bank, and 30^{0} left-bank. Eight levels of heading were used: four primary compass headings (N, S, E, W) and four intermediate compass headings (NE, SE, NW, SW). The posttest items were systematically selected to represent equally the variations in heading, pitch, and roll.

Design and Data Analyses--The pretest-treatment-posttest experimental design used in the present study was a 2 x 2 factorial design. Analyses of variance were made to determine the effects of practice and incentive on (a) posttest scores, (b) posttest rates of responding, and (c) instructional times. The results of each analysis were tested at the .05 level of confidence.

Results

Posttest Scores--The mean scores by treatment on the 36-item posttest are shown in Table 1. The mean scores of the four treatment groups were all within one point of the overall mean score of 33.31. The posttest scores were analyzed using an analysis of variance. The F-ratios for incentive, practice, and the interaction of incentive and practice, as shown in Table 2, were not statistically significant.

An increase in the accuracy of performance was observed between the pretest scores and the posttest scores. On the pretest, Ss answered a mean of 69.4% of the items correctly. On the posttest, Ss answered a mean of 92.5% of the items correctly.

Posttest Rate of Responding--Subjects spent differential amounts of time answering the items on the posttest. The time for each S was converted to a rate of responding by dividing the total number of items by S's completion time. The rates of responding were then compared to determine whether or not they were affected by the experimental variables. The mean rates of responding by treatment are reported in Table 3. The mean rate of the incentive group, 5.38 items per minute, exceeded the mean rate of 4.28 of the no incentive group. The mean rate of 5.42 of the practice group exceeded the mean rate of 4.24 of the no practice group. The differences in rates of responding were analyzed using an analysis of variance. The results of the analysis, as shown in Table 4, revealed that the difference attributable to practice was significant at the .001 level of confidence. The difference attributable to incentive was also statistically significant

TABLE 1

Mean Posttest Scores by Treatment

(Number Correct of 36 Possible Points)

Incentive	Practice		Totals
	Practice	No Practice	
Incentive	33.33	32.42	32.88
No Incentive	33.50	34.00	33.75
Totals	33.42	33.21	33.31

N = 12 per cell

TABLE 2

Analysis of Variance: Posttest Scores

Source of Variation	SS	df	MS	F-Ratio	
Incentive	9.19	1	9.19	1.12	NS
Practice	.52	1	.52	.06	NS
Incentive X Practice	6.02	1	6.02	.73	NS
Within	360.58	44	8.20		

NS = Not Significant

TABLE 3

Mean Posttest Rates of Responding by Treatment

(Items Answered Per Minute)

Incentive	Practice		Totals
	Practice	No Practice	
Incentive	6.15	4.61	5.38
No Incentive	4.69	3.88	4.28
Totals	5.42	4.24	4.83

N = 12 per cell

TABLE 4

Analysis of Variance: Posttest Rates of Responding

Source of Variation	SS	df	MS	F-Ratio	
Incentive	14.40	1	14.40	22.15*	
Practice	16.56	1	16.56	25.48*	
Incentive X Practice	1.54	1	1.54	2.37	NS
Within	28.70	44	.65		

* $p < .001$

NS = Not Significant

at the .001 level of confidence. The interaction of incentive and practice was not statistically significant.

The Ss in the treatment group that read the instruction without either practice or the incentive responded at about the same rate on the posttest as they had responded on the pretest. Their mean rate of responding was 3.98 items per minute on the pretest. On the posttest, their mean rate of responding decreased slightly to 3.88 items per minute. It appears that the rate of responding was relatively unaffected by the instructional materials.

Instructional Times--In the comparison of instruction treatments, another factor worth consideration is the effect of each experimental variable on instructional time. In the present study, comparisons were made to determine whether the practice or the incentive influenced the amount of time that Ss spent completing the instructional materials. The mean values for instructional times by treatment are shown in Table 5. It can be seen from the table that the mean instructional time of 5.11 minutes for the incentive group was less than the mean time of 6.63 for the no incentive group. An analysis of variance of instructional times, reported in Table 6, revealed that the difference between the time of the incentive group and the time of the no incentive group was significant at the .01 level of confidence.

Practice, on the other hand, led to an increase in instructional time compared to the no practice condition. The practice group had a mean time of 8.13 minutes, which is more than twice the mean time of 3.61 of the no practice group. An analysis of variance revealed a significant difference

TABLE 5

Mean Instructional Times by Treatment

(Minutes)

Incentive	Practice		Totals
	Practice	No Practice	
Incentive	7.08	3.15	5.11
No Incentive	9.17	4.08	6.63
Totals	8.18	3.61	5.87

N = 12 per cell

TABLE 6

Analysis of Variance: Instructional Times

Source of Variation	SS	df	MA	F-Ratio	
Incentive	27.38	1	27.38	11.04*	
Practice	244.13	1	244.13	98.44**	
Incentive X Practice	3.94	1	3.94	1.59	NS
Within	109.06	44	2.48		

* $p < .01$

** $p < .001$

NS = Not Significant

at the .001 level of confidence between the instructional time of the practice group and the time of the no practice group.

Discussion

The present study was conducted to determine the effects of practice and incentive on learner posttest performance on an aircraft instrument comprehension task. The results of the study did not indicate that either variable significantly affected the accuracy of responding on the posttest. Ss in the treatment group that simply read the instructional materials had a mean score of 34 on the 36-item posttest. Such a high mean score left little room for improvement that could be attributed to either the practice or the incentive variable. The increase in accuracy that was observed between the pretest and the posttest appears to be attributable to the instructional materials.

Although no significant differences in accuracy of responding resulted from the manipulation of the experimental variables, differences attributable to practice and to incentive were observed in the posttest rate of responding. The rate of responding was significantly increased both by the incentive that was offered and by the practice that was provided.

The rate of responding is an important aspect of the instrument comprehension task in that it indicates the rate at which pilots read instruments accurately and quickly is a highly desirable skill to acquire in pilot training.

The rate of responding is often considered to be a good indicator of an individual's productivity. Judgments about individuals in work situations are often based on the amount of work that an individual produces, as

well as, the quality of the work. Tests that measure the rate of responding, such as tests for typing and reading, are used to predict the quantity of work that an individual can produce. Quantitative measures are especially important in the comparison of individuals whose work is qualitatively comparable. The results of this study indicate that practice and incentive could potentially affect an individual's productivity by increasing the rate at which he can perform a task.

A difference in the rate of responding attributable to incentive was observed in the present study. The incentive was contingent upon both the speed and the accuracy of Ss' responses. In the "no incentive" condition, however, neither speed nor accuracy was reinforced. It is likely that Ss in the incentive condition were attempting to respond as fast as they could without making errors. Ss in the "no incentive" group, however, were probably trying to answer correctly without attempting to answer rapidly. The incentive, therefore, most likely served to increase the Ss' efforts on the posttest rather than to increase their ability to respond rapidly. On the other hand, the shorter instructional time of the incentive group indicates that these Ss may have practiced fast responding during the instruction. This practice could have increased their ability, not just their efforts, to answer rapidly on the posttest.

The increased rate of responding attributable to practice in the present study was achieved at the expense of an increase in instructional time, since the booklets containing practice were longer than the booklets without practice. Whether or not the additional instructional time is justified by the increased rate of responding is a matter of judgment. In making such judgments, consideration should be given to the nature of the

task. For example, if one's safety depended on a short reaction time, as in an aircraft navigation task, the value of the rate of responding would be different than if one's safety depended only on an accurate response.

Recommendations for Future Studies--The series of studies to determine the variables that are contributing to the effectiveness of the aircraft instrument comprehension program indicates that feedback, practice and incentive have not significantly affected the accuracy of learner responses on the posttest. It appears that the instructional materials are making the major contribution to the accuracy of learner responses. Instruction could be manipulated in a future study in order to verify its contribution to posttest responses.

The results of the present study indicate that practice and incentive may produce statistically significant increases in the rates of responding, but not in the accuracy of responding, when they are used in combination with an effective instructional program. Since practice and incentive are generally considered to facilitate learner achievement, it is hypothesized that the findings of the present study are generalizable only to learning situations that use instructional materials that are effective in attaining the instructional objectives. One method of testing this hypothesis might be to administer the aircraft instrument comprehension program to learners who score low on the pretest. If the program is less effective with these learners, then practice and incentive might make a significant contribution to learner performance. The generalizability of the present findings could also be tested by varying practice and incentive with different instructional materials that are less effective than the materials used in the present study. Future research about the conditions under which practice

and incentives facilitate learning should enable instructional designers to more effectively incorporate these two variables into instructional programs.

The following supporting documents are in the R & D Case File at Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224:

Higgins, N. C. Aircraft instrument comprehension program: Form B. (AFSC Contract No. F41609-71-C-0027, Task Order No. 3) Tempe, Arizona: Arizona State University, 1973.

Higgins, N. C., & Kearns, D. R. Validation report: Aircraft instrument comprehension: A self-instructional program: Form A. (AFSC Contract No. F41609-71-C-0027 Task Order No. 3) Tempe, Arizona: Arizona State University, 1973.

Higgins, N. C., Kearns, D. R., & Tenpas, B. G. Validation report: Aircraft instrument comprehension: A self-instructional program: Form B. (AFSC Contract No. F41609-71-C-0027, Task Order No. 3) Tempe, Arizona: Arizona State University, 1974.

Kearns, D. R., Tenpas, B. G., & Higgins, N. C. Aircraft instrument comprehension test: Form B. (AFSC Contract No. F41609-71-C-0027, Task Order No. 3) Tempe, Arizona: Arizona State University, 1973.

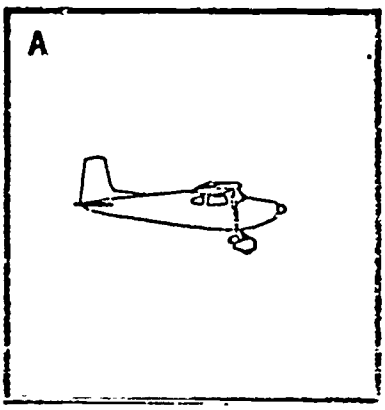
APPENDIX A

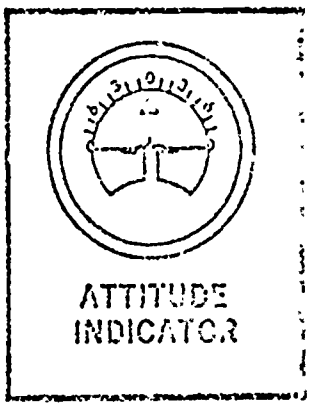
Sample Instructional Materials

Attitude Indicator-Pitch

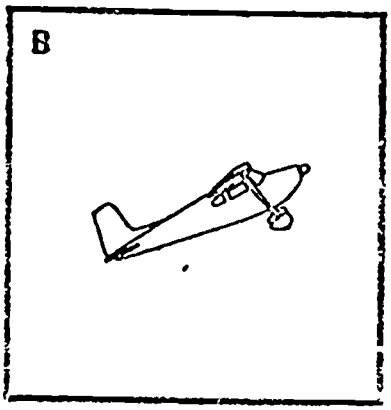
The instrument labeled attitude indicator shows whether the airplane is climbing or diving. This instrument also shows the degree of bank to the right or left.

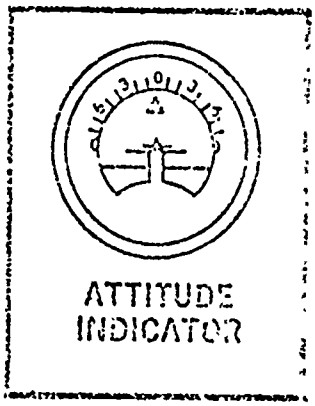
The small aircraft silhouette in this instrument remains stationary. The position of the heavy black line, representing the horizon, varies with the airplane's position.



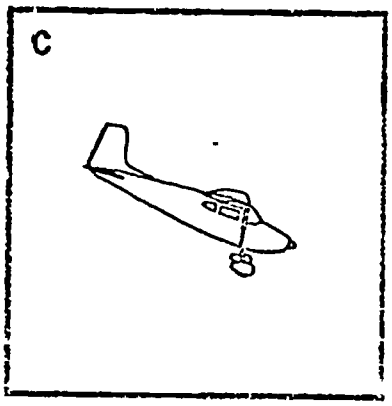


When the airplane is flying level, the horizon line will be directly on the aircraft silhouette as shown above.



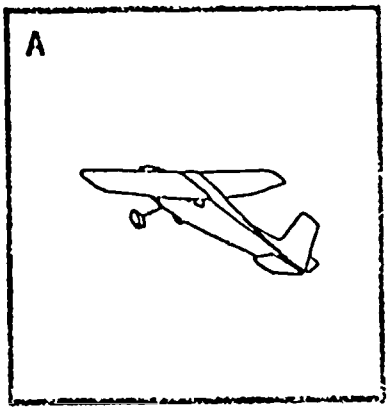


If the airplane is climbing, the silhouette is seen between the horizon line and the triangular pointer.

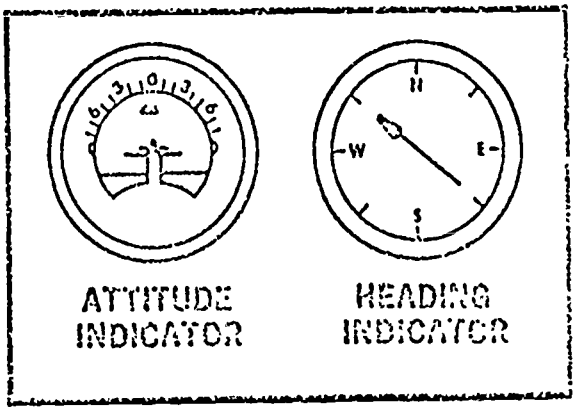


If the airplane is diving, the horizon line will be between the silhouette and the pointer.

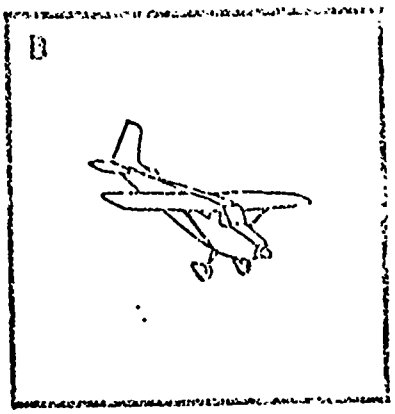
The airplane in Figure A is climbing on a northwest heading.



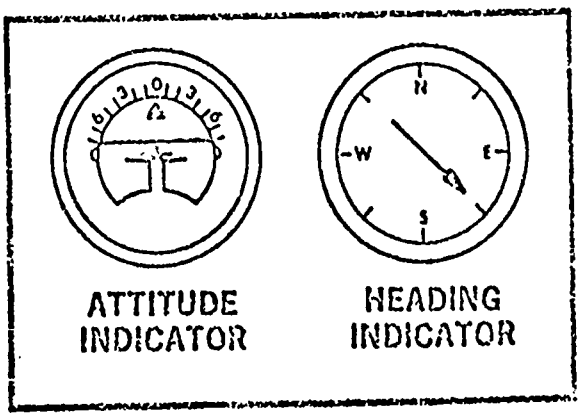
The horizon line is below the aircraft silhouette in the attitude indicator. The arrow in the heading indicator is pointing midway between the N and the W.



The airplane in Figure B is diving on a southeast heading.



The horizon line is above the aircraft silhouette in the attitude indicator. The arrow in the heading indicator is pointing midway between the S and the E.

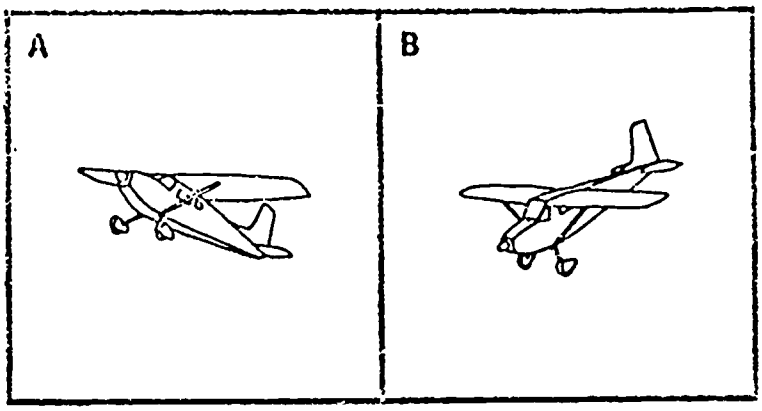


APPENDIX B

Sample Practice Items

Which of the airplanes pictured below is most nearly in the position indicated on the attitude and heading indicators?

Mark your choices opposite items 2 and 3 on the response sheet.



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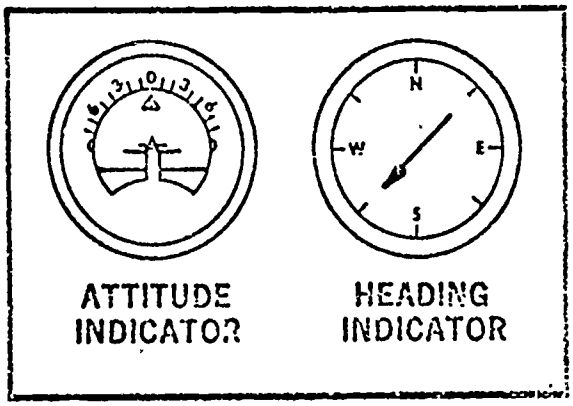

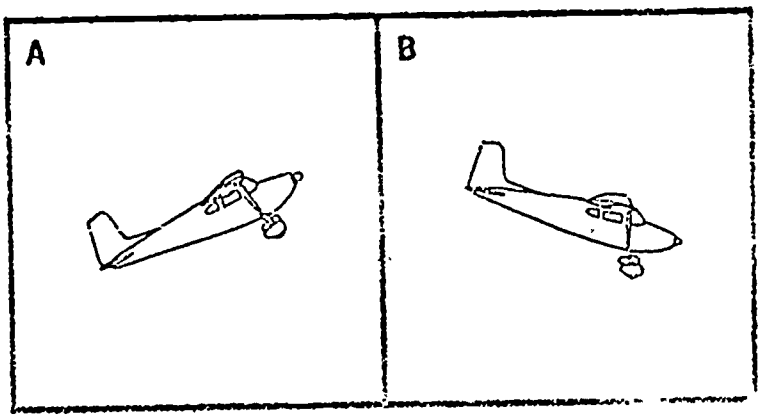

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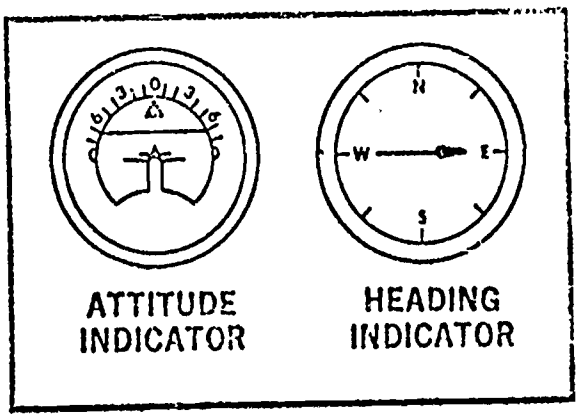
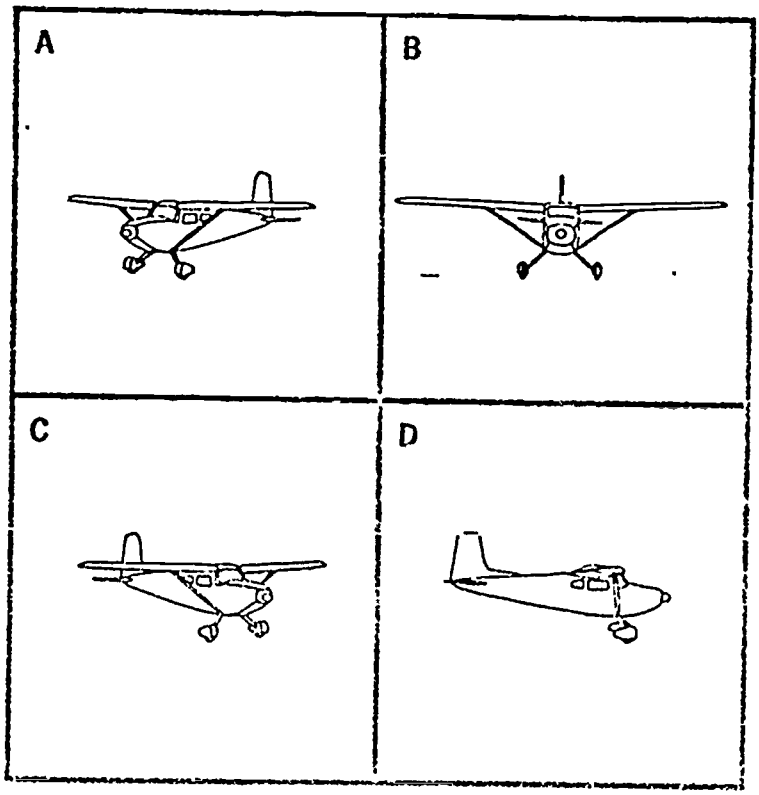
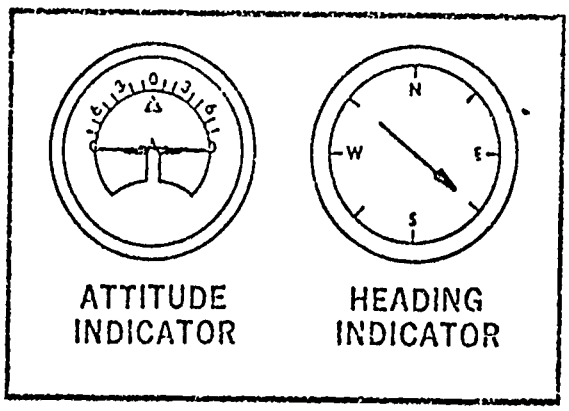


Which of the aircraft pictured below is in the position shown on the instrument panel?

Mark your choice opposite item number 4 on your response sheet.



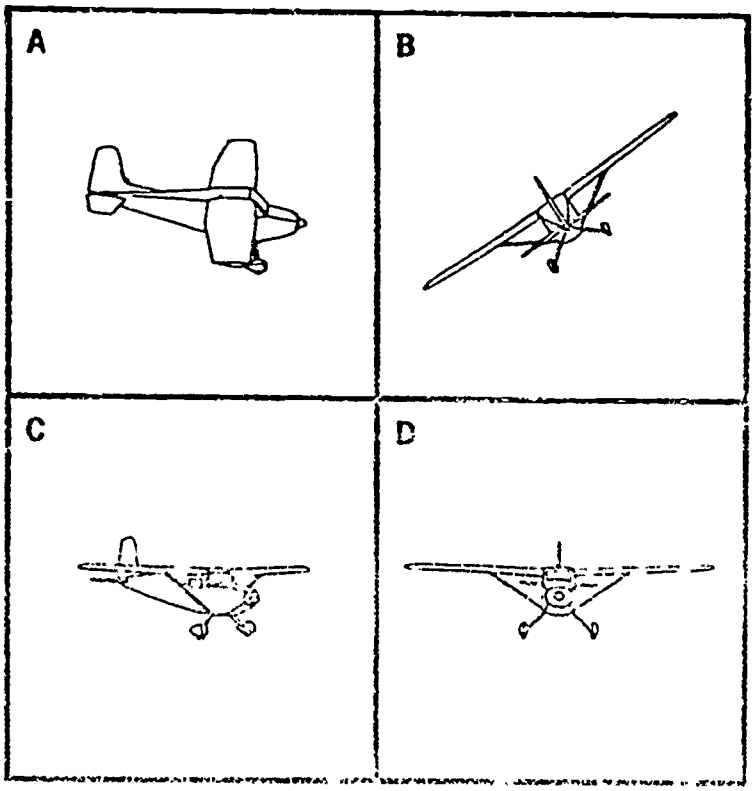
4.



APPENDIX C

Sample Posttest Item

Sample Posttest Item



X.